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TENSION WOOD IN EASTERN COTTONWOOD

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FOREST SERVICE

This report is from the
CENTRAL STATES FOREST EXPERIMENT STATION

W. G. McGinnies, Director

Carbondale (Illinois) Forest Research Center
(Maintained in cooperation with the
Forestry Department,
Southern Illinois University, Carbondale, Illinois)

Richard D. Lane, Forester in Charge

and

U. S. Forest Products Laboratory
Madison, Wisconsin

Tension Wood in Eastern Cottonwood

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and

MAXON Y. PILLOW, technologist[1/]

"Tension wood" is an abnormal wood structure that occurs in several species of hardwood. It consists of widely varied numbers of a type of wood fiber known as "gelatinous fibers," so called because of the peculiar composition of the inner cell walls. This condition often causes serious longitudinal warping and some collapse in lumber and buckling of veneer.[2/] Moreover, such wood usually leaves a fibrous or fuzzy surface when machined.

Observers have found that in some species, tension wood seems to be concentrated on the upper sides of leaning trees. It is felt that, because of the lean, the wood in this section is under greater tension than normally, hence the unnatural structure and the name "tension" wood.

1/ Forest Products Laboratory, Forest Service, U. S. Department of Agriculture, maintained at Madison, Wisconsin, in cooperation with the University of Wisconsin.

2/ Pillow, Maxon Y. Effects of tension wood in hardwood lumber and veneer. Forest Prod. Lab. Rpt. R1943, 6 pp., illus., April 1953.

Recently, through the cooperation of Southern Illinois University, the U. S. Forest Products Laboratory, the Shawnee National Forest, and the Central States Forest Experiment Station, a study was made to find out how the lean of a tree influences the occurrence and position of tension wood in eastern cottonwood (Populus deltoides Bartr.). The results of this study are reported here.

Although studies of tension wood in numerous species have shown that it occurs chiefly on the upper sides of leaning trees[3], a recent study of aspen showed that, while the greatest concentrations of the abnormal fibers were on the upper sides of leaning trees, there were also some on the lateral and lower sides.[4] Concentrations of the gelatinous fibers distinguish abnormal tension wood from the typical structure of hardwood species. So, for the present study of eastern cottonwood, three major objectives were set up.

1. Find out where in the trees tension wood commonly occurs in relation to lean of the tree at breast height.

2. Find out how the amount of lean affects the amount of tension wood.

3. Find out if tension wood occurs more commonly in the lower part of the bole, near the middle, or at the top.

Sources of Sample Trees and Procedures

The sample trees were obtained from the Pottsville Tract of the Shawnee National Forest, a fairly typical bottom-land stand consisting mainly of eastern cottonwood. Many of the cottonwood trees leaned various amounts, most commonly between about 4 and 8 degrees. The actual amount of lean for each of the experimental trees was measured at breast height with a simple plumb-bob device. The trees selected for this study leaned 1, 4, 8, and 12 degrees, generally were vigorously growing, and were about 30 years old.

3/ Akins, Virginia and Pillow, Maxon Y. Occurrence of gelatinous fibers and their effect upon properties of hardwood species. Forest Prod. Res. Soc. Proc. 1950, 11 pp., illus.

4/ Terrell, Bessie Z. Distribution of tension wood and its relation to longitudinal shrinkage in aspen. Forest Prod. Lab. Rpt. R1917, 6 pp., illus., February 1952.

The almost vertical tree (1 degree lean) had a large, symmetrical crown and practically straight trunk throughout its length. In contrast, the trees with greater lean (4, 8, and 12 degrees) had more or less one-sided and somewhat smaller crowns. The trunk of each of the latter trees also had some sweep but usually was more nearly vertical 20 or more feet above the ground.

Cross-sectional disks approximately 3 inches thick were taken from each of the sample trees at breast height and approximately the middle and top of the merchantable length of the trunks. The upper side of each tree in relation to lean at breast height was marked on each disk regardless of any crookedness of the trunk that might affect direction of lean at the heights of the upper disks. This made it possible to find out whether lean at breast heights affected location of tension wood in the upper parts of the trunk in the same way as at breast height.

Samples for determining the presence of the gelatinous fibers were taken along three pairs of radii passing through the pith. Two pairs of radii represented the upper or lower sides of the lean at breast height, and the third pair represented the diameter of the disks at the sides of the lean (fig. 1). The samples of wood were taken within the same annual rings along each of the six radii about 2 inches apart. Each sample ranged from 15 to 20 microns in thickness and included an area of about 1 inch tangentially by 3/4 inch radially. Thus, in the present study, specific annual rings were sampled in the entire cross section instead of essentially an outer zone of wood around the tree as was done for aspen.

Occurrences and Distributions of Gelatinous Fibers

Two significant relationships were brought out in the present study: (1) At breast height, gelatinous fibers in cottonwood were concentrated on the upper side of the tree's lean; and (2) the amount of gelatinous fibers or tension wood increases with increasing lean in a tree (table 1 and fig. 2). At the middle and top heights, however, the greatest concentrations of gelatinous fibers frequently occurred on the lower or lateral sides of the trees. Moreover, more gelatinous fibers were found at the middle and top heights in the tree that leaned only 1 degree than at breast height (fig. 3, p. 8). On the other hand, the trees with greater lean (4, 8, or 12 degrees), tended to have somewhat fewer gelatinous fibers at the middle and top heights than at breast height, and these were more uniformly distributed around the boles. The moderately leaning tree (4 degrees) had many more gelatinous fibers along one radius than the other on the upper side, but the more severely leaning ones (8 and 12 degrees) had large numbers along both the upper radii at breast height (fig. 3, p. 8, and fig. 4, p. 9).

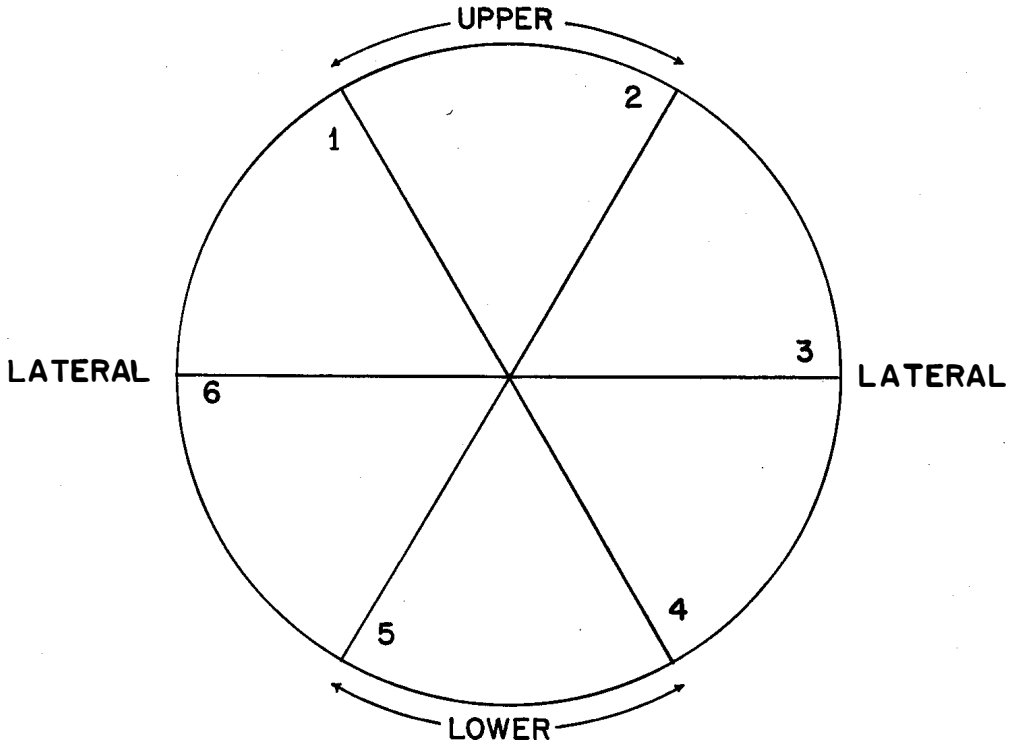

Figure 1.--Diagram of disk from trunk of tree to show number of each radius in relation to upper, lateral, and lower sides of lean.

A simple analysis of variance showed that the greatest number of gelatinous fibers were related only at breast height to amount and direction of lean (upper side). The shifting of the greatest numbers of those fibers at the middle and top heights in relation to the concentrations at breast heights was associated with sweep and frequently some crookedness in the boles in the moderately and severely leaning trees. Nevertheless, there was an anomalous occurrence of relatively large concentrations of those fibers in the essentially vertical tree (1 degree) in certain radii at the middle and top heights that were not identified with observed sweep or crook in the trunk.

Table 1.--Number of gelatinous fibers on upper, lateral, and lower radii of the lean at breast height in eastern cottonwood trees

Lean (Degrees)	Number of gelatinous fibers[1]		
	Upper radii	Lateral radii	Lower radii
AT BREAST HEIGHT			
1	6.9	2.8	0.9
	4.5	.4	1.6
4	26.2	.4	.4
	6.7	.4	.4
8	20.4	.4	.4
	24.1	.4	.4
12	39.0	15.7	.4
	49.5	.4	.4
IN THE MIDDLE			
1	16.9	14.9	6.0
	8.2	20.5	12.9
4	.4	.4	5.7
	.4	1.4	12.7
8	1.3	.4	.4
	1.3	18.1	.4
12	7.8	.4	1.3
	1.9	6.7	.5
AT THE TOP			
1	14.5	25.3	34.8
	15.2	16.8	30.6
4	.4	.4	.5
	.4	1.3	8.6
8	2.2	.5	14.4
	1.9	14.4	15.2
12	4.0	8.6	13.9
	11.4	4.1	15.5

1/ Calculated from distributions and frequencies estimated by microscopical examinations by the following formula: $\text{Number} = \frac{\text{Distribution X Frequency}}{100}$.

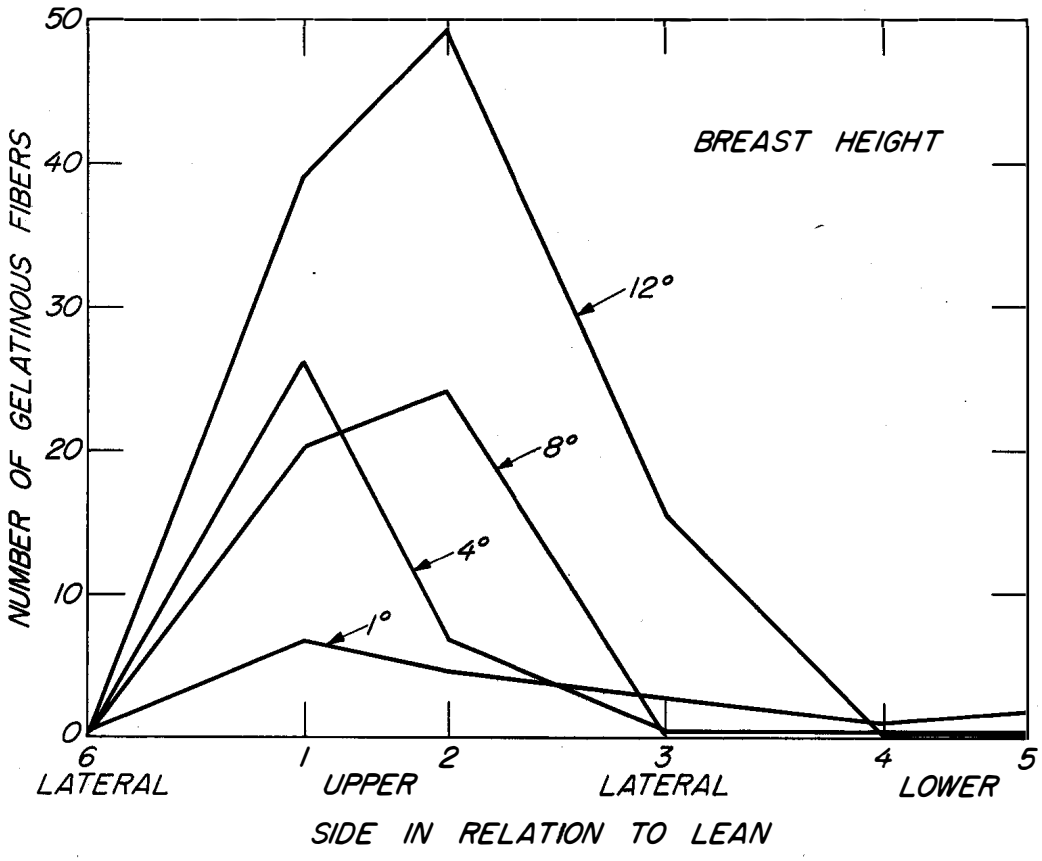

Figure 2.--Number of gelatinous fibers on upper, lower, and lateral sides of leaning eastern cottonwood trees at breast height.

Applications to Forest Management

This information on occurrence of tension wood has some important implications to management of eastern cottonwood stands. For example, the present study has shown relatively large concentrations to be most frequent on the upper sides of severely leaning trees, particularly in the lower parts of the trunks. On the other hand, the smaller concentrations of those fibers on the upper and lateral sides of the lean in eastern cottonwood, as also in aspen, usually result in minor or negligible longitudinal warping of lumber and buckling of veneer. So, in order to produce cottonwood timber with the satisfactory qualities for lumber and veneer,

it is highly desirable to restrict the amounts of lean of the trees as far as is consistent with other silvicultural factors. Tension wood can be minimized by favoring vertical trees or those that lean less than 4 degrees. Not only can the abnormal wood structure be expected to be at a minimum in such trees, but also the form of the trees undoubtedly will be more desirable.

Restricting lean to 4 degrees or less provides a starting place for the management of natural or planted stands of cottonwood. Such a restriction logically should be applied early in the management of the stands in precommercial and intermediate thinnings and cuttings. Thus, the ultimate crops of cottonwood timber produced could be expected to have the qualities necessary for lumber and veneer.

SUMMARY

A study of gelatinous fibers (tension wood) in eastern cottonwood showed:

1. Relatively large concentrations of those fibers in trees leaning 8 to 12 degrees at breast height.

2. In contrast, the essentially vertical or only slightly leaning trees (1 to 4 degrees) had fewer gelatinous fibers at breast height.

3. Restricting lean by removing early trees leaning more than 4 degrees wherever silviculturally possible undoubtedly will minimize the formation of tension wood in eastern cottonwood stands.

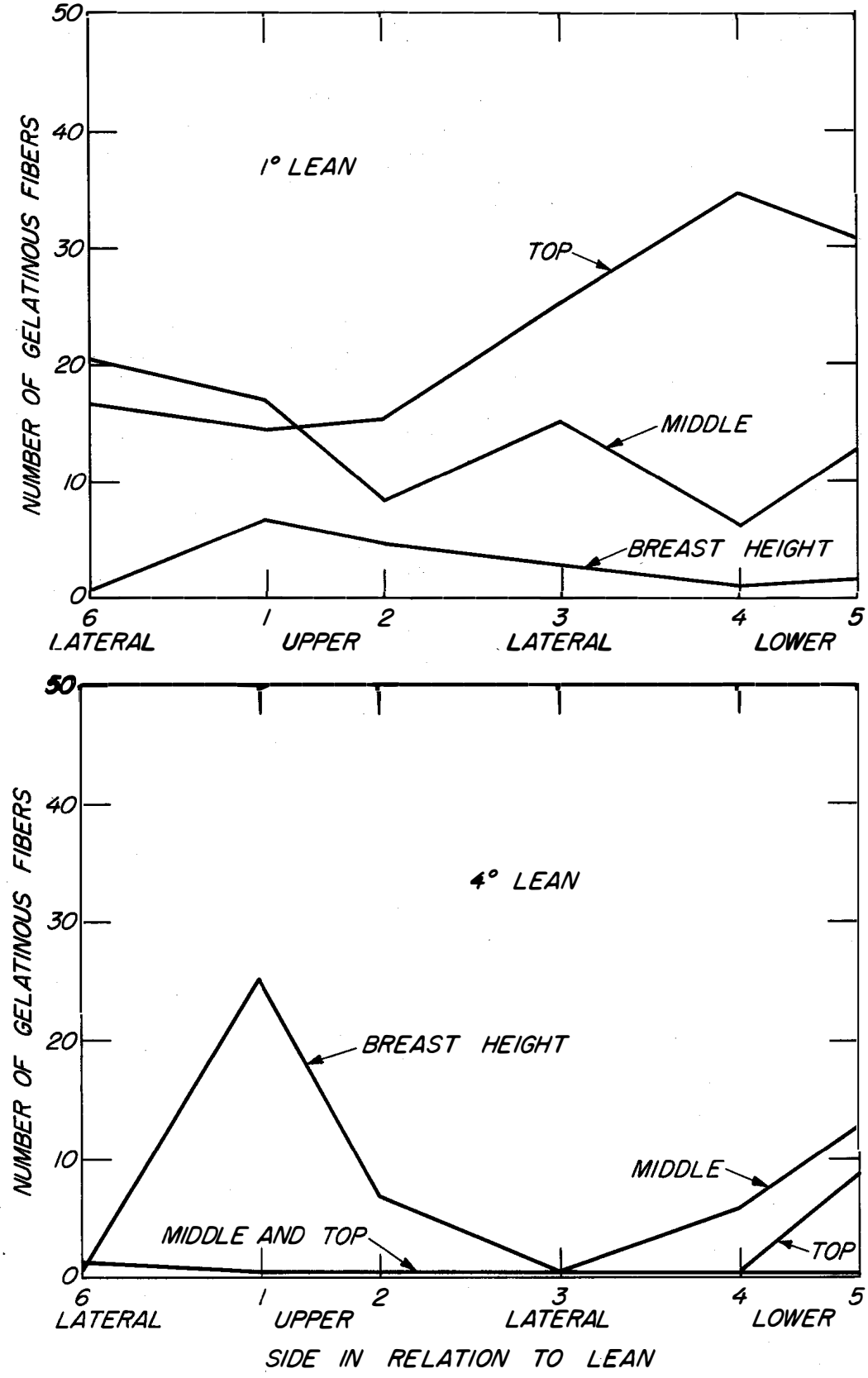

Figure 3.--Number of gelatinous fibers in eastern cottonwood tree leaning 1 degree (top) and 4 degrees (bottom).

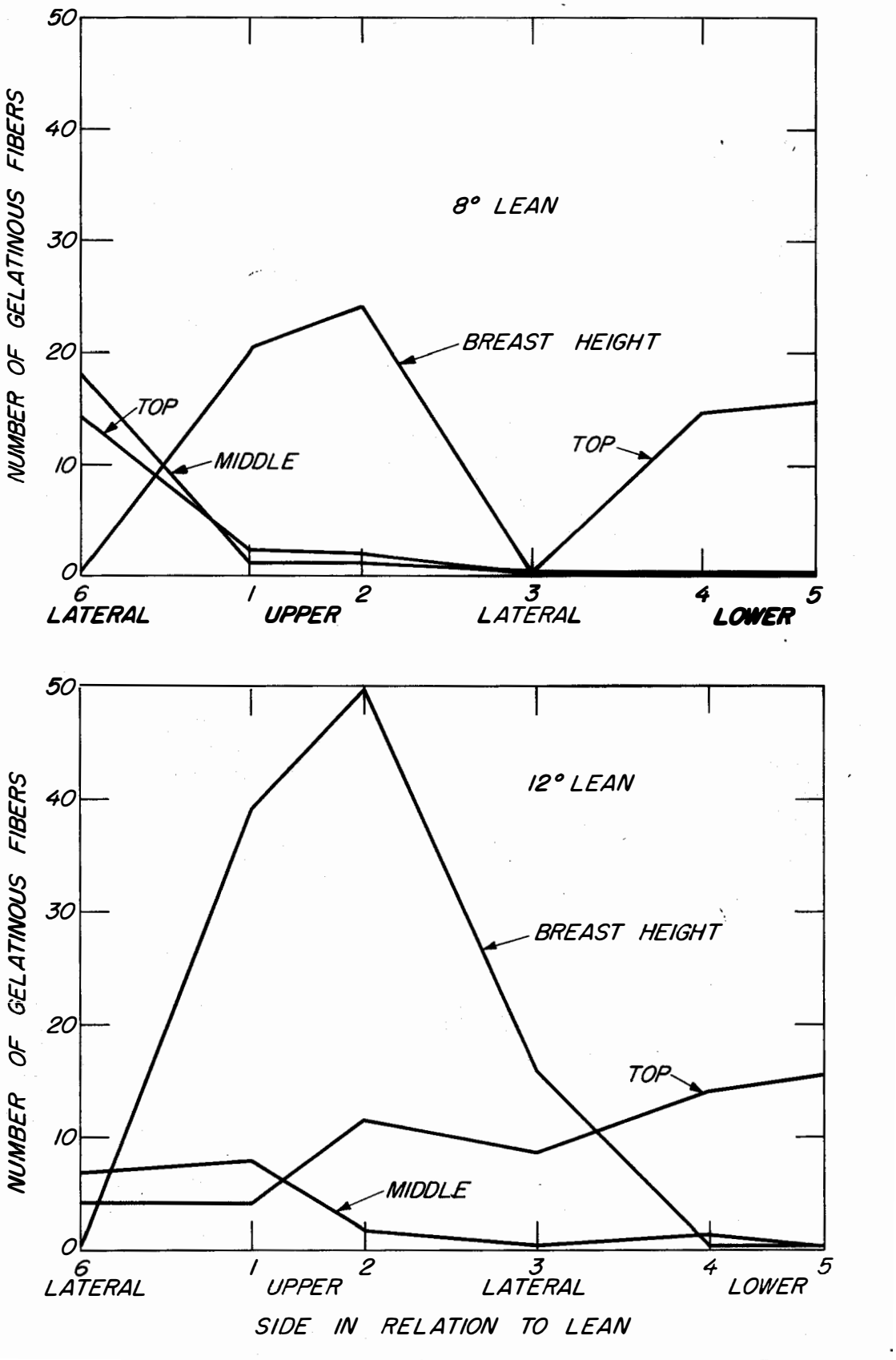

Figure 4.--Number of gelatinous fibers in eastern cottonwood tree leaning 8 degrees (top) and 12 degrees (bottom).

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